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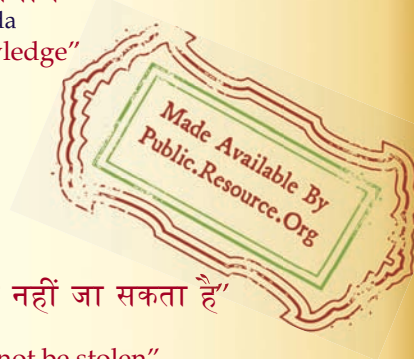
IS 7808 (1975): Code of Procedure for Conducting Studies on Underground Corrosion of Metals [MTD 24: Corrosion Protection]



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“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

CODE OF PROCEDURE FOR CONDUCTING STUDIES ON UNDERGROUND CORROSION OF METALS

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CODE OF PROCEDURE FOR CONDUCTING STUDIES ON UNDERGROUND CORROSION OF METALS

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Indian Standard

CODE OF PROCEDURE FOR CONDUCTING STUDIES ON UNDERGROUND CORROSION OF METALS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 22 July 1975, after the draft finalized by the Corrosion Protection Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This code has emerged as a result of investigations instituted by the Corrosion Advisory Bureau of the Metals Research Committee of Council of Scientific and Industrial Research (CSIR). In the formulation of this standard considerable assistance has been derived from the document, prepared by Corrosion Advisory Bureau on this subject.

0.3 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down procedure for conducting studies on underground corrosion of metals.

2. TERMINOLOGY

2.0 For the purpose of this code, the definitions given in IS : 3531-1966† shall apply.

3. EXPOSURE SITE

3.1 The test sites should be so selected as to represent all types of soils mentioned below. In selection of sites, industrial or strategic importance

*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to corrosion of metals.

of the site shall be kept in consideration. Examples of sites for each type of soil have been given in brackets:

1. Alluvial soil (undifferentiated) (Calcutta, Tezpur, Delhi, Namrup)
2. Coastal alluvium (Bombay, Madras, Vishakhapatnam, Ratnagiri, Karaikudi)
3. Grey and Brown soils of Indus, Jamuna and Gangetic basin impregnated with salts (Kanpur, Mugalsarai)
4. Gangetic alluvium (calcareous) (Dehradun)
5. Saline and deltaic soils (Diamond Harbour, Digha)
6. Deep black soil or regur soil of valleys (tarai)
7. Medium black soil of trap and gneissic origin (plateau) (Hyderabad, Nagpur)
8. Shallow black soils (Amla)
9. Mixed red and black soils (Jamshedpur, Jhansi)
10. Red loam (Salem, Madurai)
11. Red gravelly soils (Mysore)
12. Red and yellow soils (Salaya)
13. Laterites (high and low level) (Bangalore, Bhubaneshwar)
14. Laterite soils (old alluvium)
15. Desert soils (grey and brown) (Jodhpur)
16. Skeletal soils (Jabalpur)
17. Forest and hill soils (undifferentiated) (Siliguri)
18. Sub-montane regional soils (undifferentiated) (Jammu)
19. Foothill swampy soils (undifferentiated) (Pilibhit)
20. Peat soils (Cochin)

3.2 A soil map of India, showing the types of soils and suitable exposure sites is given in Fig. 1. The classification of the soils has been made by Indian Agricultural Research Institute, New Delhi.

4. TEST SPECIMENS

4.1 The test specimens to be exposed shall be cast iron pipes (horizontally cast and spun), galvanised steel pipe, mild steel pipe, aluminium pipe, mild steel plates, copper plates, aluminium cable and lead cable. Mild steel plates will be treated as reference plates. Metal rods may be used if metal pipes are not available. All metals and cables used shall conform to appropriate Indian Standards. Other metals may also be used, if desired.



THE TERRITORIAL WATERS OF INDIA EXTEND INTO THE SEA TO A DISTANCE OF TWELVE NAUTICAL MILES MEASURED FROM THE APPROPRIATE BASE LINE

BASED UPON SURVEY OF INDIA MAP WITH THE PERMISSION OF THE SURVEYOR GENERAL OF INDIA

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- | | |
|--|---|
| 1. Alluvial soils (undifferentiated) | 11. Red gravelly soils |
| 2. Coastal alluvium (new) | 12. Red and yellow soils |
| 3. Grey and Brown soils of Indus, Jamuna and Gangetic basin impregnated with salts | 13. Laterites (high and low level) |
| 4. Gangetic alluvium (calcareous) | 14. Laterite soils (old alluvium) |
| 5. Saline and deltaic soils | 15. Desert soils (grey and brown) |
| 6. Deep black soil or regur soil of valleys | 16. Skeletal soils |
| 7. Medium black soil of trak and gneissic origin (plateau) | 17. Forest and hill soils (undifferentiated) |
| 8. Shallow black soils | 18. Sub-montane regional soils (undifferentiated) |
| 9. Mixed red and black soils | 19. Foothill swampy soils (undifferentiated) |
| 10. Red loam | 20. Peat soils |

FIG. 1 SOIL MAP OF INDIA

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5. SIZE OF SPECIMENS

5.1 The pipe/rod specimens shall be 50 to 80 mm in diameter and 225 to 300 mm in length. The length of cable specimens shall be 225 to 300 mm. The plate specimens shall be of $200 \times 300 \times 3$ mm size.

6. IDENTIFICATION AND MARKING OF TEST SPECIMENS

6.1 The identification of a specimen or a set of specimens shall consist of either punching of an identifying letter and numbers alongwith the year of burial or making drills or cuts on one side of the specimens. In case of pipes, a reference cut 10 mm deep and 5 mm in width shall be made at one end of the pipe and a 5 to 7 mm diameter hole may be drilled along the base line of the reference cut. The distance of the hole in centimetres from the reference cut measured from centre to centre in clockwise direction will indicate the number of the specimen.

6.2 In case, the pipe specimens are used with plugged (closed) ends, identification letter/number and year shall be punched on a 25×50 mm, aluminium sheet and shall be placed inside the tube, before plugging the ends.

6.3 For plate specimens, numbering shall be made by drilling holes as specified for the master plate, the sketch of which is given in Fig. 2.

6.4 The form and dimensions are also helpful in identifying the specimens.

6.5 Details of the position of test specimens in the trench will be drawn and the record kept in triplicate. The identification number, form, size and composition of different specimens shall be noted on the drawing for future reference. Generally, position of the specimen in the trench will indicate the type of the specimen.

7. PREPARATION AND CLEANING OF TEST SPECIMENS

7.1 The test specimens shall be free from surface contamination like dust, grease and oily matter. All the metal specimens shall be rubbed with cotton soaked in some suitable solvents, such as kerosene, petroleum solvent, trichlorethylene, benzene free from sulphur, or alcohol to remove grease, dust and any other adhering extraneous substances. Brushing with hard bristle brush for removal of oxide coating may be used, if necessary taking care not to cause any scratches or other defects.

7.2 Mild steel plate may be pickled for removal of mill scale. After pickling, the metal surface shall be finished with emery paper No. 0 and degreased with suitable solvents.

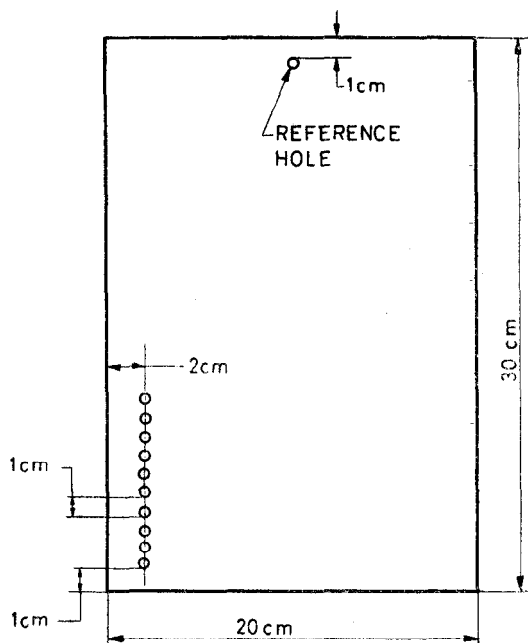
7.3 The cable specimens should be used as such after superficially cleaning with cloth or cotton.

7.4 Test specimens other than cables shall be weighed before the exposure test. Weighing up to an accuracy of 1 g for mild steel plate and aluminium pipe and of 10 g (preferably 2 to 5 g) for heavier specimens shall be sufficient.

7.5 Measurements of depths of pits already present on test specimen shall be recorded with the help of a micrometer or travelling microscope.

7.6 If closed pipes are used as specimens, the internal surface of the pipe should be coated with a good corrosion preventing composition like grease and mineral jelly-bees wax mixture, and the ends should be water-sealed with bitumen or some other suitable compound.

7.7 Preparation of the test specimens such as cleaning, identification, weighing, etc, should be made at the various test centres.



NOTE — The position of the holes at left hand side of the specimen at a distance in centimetres from the bottom will indicate the number of the specimen.

FIG. 2 SKETCH OF THE MASTER PLATE FOR NUMBERING THE PLATE SPECIMENS

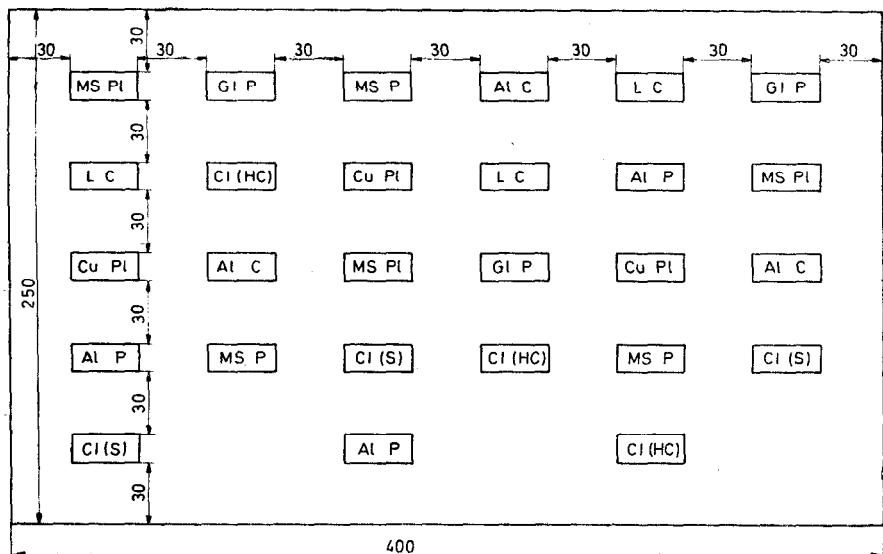
8. EXPOSURE OF TEST SPECIMENS

8.1 Soil resistivity of the ground, where trenches are to be dug for exposure, shall be determined by Wenner's Four Terminal method, as described in Appendix A.

8.2 Three specimens of each type of the material shall be buried in each trench. In total 108 specimens of nine types of materials shall be exposed in four trenches for the test. The test specimens shall be buried in a wall

of four trenches are shown in Fig. 4.

8.3 The pipe/rod specimens shall be buried vertically with both ends open and packed with the soil with approximately the same compactness as of the original soil. The end (of the pipe) with the reference mark should be at the top. The plate and cable specimens shall also be placed vertically in the trench.



MS P — Mild steel pipe CI (HC) — Cast iron horizontal cast pipe Al C — Aluminium cable
 MS Pl — Mild steel plate GI P — Galvanized iron pipe L C — Lead cable
 CI (S) — Cast iron spun pipe Al P — Aluminium pipe Cu Pl — Copper plate

All dimensions in centimetres.

FIG. 3 POSITION OF SAMPLES IN EACH TRENCH

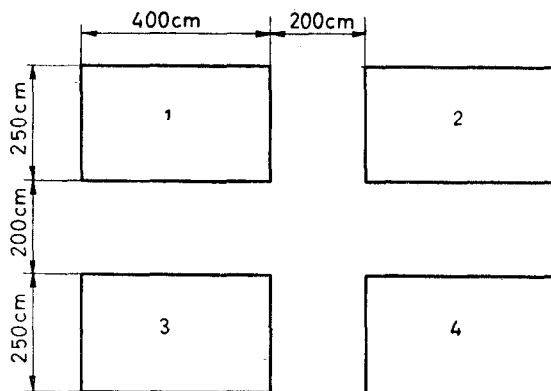


FIG. 4 POSITION OF FOUR TRENCHES

8.4 The specimens shall be placed about 30 cm apart to avoid one specimen affecting the corrosion of another by galvanic action and to facilitate the removal of selected specimens without disturbing the soil near the other.

8.5 The depth at which the specimens shall be placed shall be approximately 100 cm.

8.6 The specimens shall be buried in the same soil horizon; the texture and physical and chemical properties of which have been determined beforehand. Four soil samples of 200 g each shall be collected from each trench for analysis. While digging, soils at different levels may be collected separately, if possible, and refilled in the same order.

8.7 Care should be taken to ensure the absence of stray electric current.

9. INSPECTION

9.1 The area of exposure shall be properly marked on the ground surface with pillars or boards. It is better if the test site is cordoned off and no work on the ground is done. The test site shall be periodically examined to check any damage of the ground surface or test specimens.

10. REMOVAL OF SPECIMENS

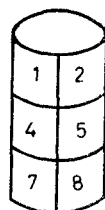
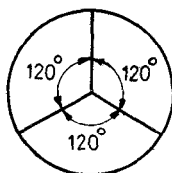
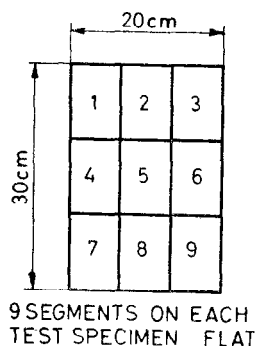
10.1 Four trenches will be opened during the exposure period of 10 years in the following manner. One trench will be opened after completion of 1 year, second one after 3 years, third one after 5 years and the last trench after 10 years.

10.2 Four soil samples of approximately 200 g each shall be collected from the opened trench from the vicinity of the specimens. Studies related to soil analysis and assessment of corrosion shall be made at a centralised place on zonal basis, if such facilities are not available at the test station.

10.3 The test specimens shall be removed from the trench and identification number noted on the cardboard shall be tied around the specimen by means of a thread. The loose dirt shall be scrapped off. The specimens shall then be cleaned first by pounding them with a small pointed hammer and finally by scrubbing under running water with a stiff wire brush.

10.4 Cable specimens after removal shall be sent to a centralised place in undisturbed condition for assessment of damage where facilities for this exist.

10.5 For convenience, each pipe or plate shall be divided into different segments as shown in Fig. 5 and numbers of pits noted with pit depths in each segment.



No. 3, 6 AND 9 ARE
AT THE BACK

9 SEGMENTS ON EACH
TEST SPECIMEN PIPE

FIG. 5 SEGMENTATION OF PIPE AND FLAT TEST SPECIMENS

11. REMOVAL OF CORROSION PRODUCTS

11.1 All the test specimens shall first be cleaned by pounding with a pointed hammer and scrubbing under running water with stiff wire brush. Mild steel and cast iron specimens shall be cleaned in Clark's solution or by cathodic cleaning.

11.2 Copper specimens shall be cleaned in 5 to 10 percent sulphuric acid solution at room temperature.

11.3 Aluminium specimens shall be cleaned either in concentrated nitric acid or in a 20 percent chromic acid plus 5 percent phosphoric acid solution at 80°C.

11.4 Galvanized steel specimens shall be cleaned in 20 percent chromic acid solution at 80°C or in a 10 percent trisodium phosphate solution at 85°C.

11.5 If hard flakes of corrosion products still remain on the specimens, these may be pounded again with the hammer, scrubbed in running water with hard bristle brush and treated in derusting solutions.

12. ASSESSMENT OF CORROSION

12.1 After removal of corrosion products, the test specimen shall be weighed and the loss in weight recorded. The rate of corrosion of various samples shall be expressed in $(\text{g}/\text{dm}^2)/\text{y}$.

12.2 Nature of corrosion attack such as uniform or localised corrosion, graphitisation in case of cast iron, red or white rusting in the case of galvanized samples shall be noted and recorded.

12.3 Measurement of pit depths on the test specimens after exposure should be carried out with the help of a travelling microscope or a micrometer with a least count of 0.025 mm.

12.3.1 Maximum pit depth and number of large pits shall be recorded.

13. DETERMINATION OF SOIL PROPERTIES

13.1 Data on the important properties of soil shall be collected at each site. The various properties to be studied and the recommended methods are given in 13.1.1 to 13.1.9.

13.1.1 pH of Soil — This shall be done in accordance with IS : 2720 (Part XXIV) - 1967*. Classification of soil reaction shall be as follows:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.6
Neutral	6.7 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

*Methods of test for soils, Part XXIV Determination of base exchange capacity.

13.1.2 Total Acidity of the Soil — This shall be measured in accordance with the methods described in Appendix B.

13.1.3 Mechanical Analysis of Soil — This shall be done in accordance with IS : 2720 (Part IV)-1965*.

13.1.4 Resistivity of Soil — This shall be measured in accordance with the methods given in Appendix A.

13.1.5 Moisture Content — This shall be measured in accordance with IS : 2720 (Part II)-1964†.

13.1.6 Apparent Density — This shall be measured in accordance with IS : 2720 (Part XXVIII)‡ or IS : 2720 (Part XXIX)-1966§.

13.1.7 Specific Gravity — This shall be measured in accordance with IS : 2720 (Part III)-1969||.

13.1.8 Volume Expansion — This shall be measured in accordance with the methods described in Appendix C.

13.1.9 Pore Space — This shall be measured in accordance with the method described in Appendix C.

14. DETERMINATION OF SOLUBLE SALTS

14.1 Determination of soluble salts in the soil shall consist of estimating sodium, potassium, magnesium, calcium, carbonate, chloride, sulphate and nitrate ions with the help of suitable methods.

15. BACTERIOLOGICAL DATA OF SOIL

15.1 The nature of soil bacteria shall be determined with particular reference to the sulphate reducing bacteria and the sulphur oxidising bacteria. For this suitable method shall be adopted.

15.2 The microbiological examination of the soil samples from all sites shall be made in a centralised laboratory possessing facilities for the same.

16. METEOROLOGICAL DATA

16.1 The meteorological data of the exposure sites such as humidity, temperature, rainfall, number of rainy days, dew formation, etc, should be

*Methods of test for soils : Part IV Grain size analysis.

†Methods of test for soils : Part II Determination of moisture content.

‡Methods of test for soils : Part XXVIII Determination of dry density of soils, in-place, by the sand replacement method.

§Methods of test for soils : Part XXIX Determination of dry density of soils, in-place, by the core-cutter method.

||Methods of test for soils : Part III Determination of specific gravity.

recorded for the entire period of test in the proforma F as shown in Appendix D.

17. RECORDING OF DATA

17.1 Recording the data of underground corrosion of metals tests shall be done in the proformas as shown in Appendix D.

APPENDIX A

(*Clauses 8.1 and 13.1.4*)

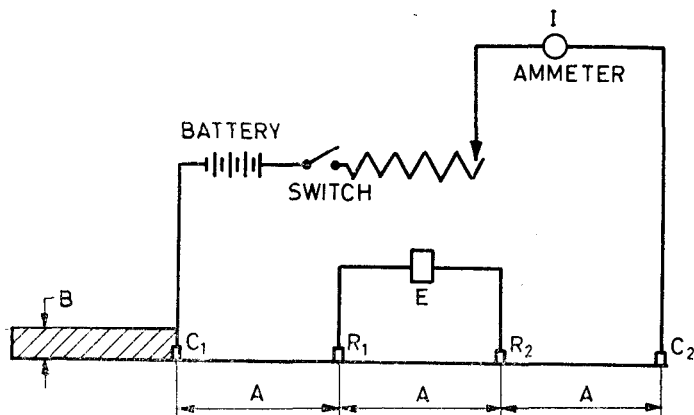
DETERMINATION OF RESISTIVITY OF SOIL SAMPLES

A-1. RESISTIVITY OF SOIL

A-1.0 Two methods for determining the soil resistivity, namely, laboratory test and field test have been described here.

A-1.1 Determination of Soil Resistivity by Four-Terminal Method (Field Test) (Wenner's Method)

A-1.1.1 This method consists of contacting the electrolyte (soil) with four electrodes usually steel pins equally spaced apart (as shown in Fig. 6).



NOTE 1 — Depth of the electrodes (B), (buried portion) shall be small, about $1/20$ th of distance (A).

NOTE 2 — The resistivity is averaged to a depth approximately equal to the electrode spacing (A).

FIG. 6 FOUR PIN METHOD FOR FIELD SOIL RESISTIVITY

A-1.1.2 Four steel electrodes, 1.25 cm diameter and 45 cm long, are driven in the soil at equally spaced distances A in a line. The depth to which they are driven should be approximately one-twentieth of A . A regulated and measured current I shall be applied between the outer terminals while the potential E between the inner electrodes R_1 and R_2 is measured. Resistivity ρ is calculated from the formula

$$\rho = 2 \pi A R, \text{ or}$$

$$\rho = 6.28 \times A \times R$$

where

R = the ratio of potential to current (E/I), and

A = electrode spacing.

In the field, I and E are measured in milliamperes and millivolts respectively. To obtain correct value of E , the following readings are taken:

mE_1 = potential in millivolts between the two inner terminals before any current has been passed between the two outer electrodes,

mE_2 = potential in millivolts between the two inner electrodes while a current mI in milliamperes has been passed between the two outer electrodes,

mE_3 = potential in millivolts between the two inner electrodes after the current between the two outer electrodes had been discontinued, and

mI = current in milliamperes passed between outer electrodes.

From these values the resistivity is obtained from the following equation

$$\rho = 6.28A \times \frac{mE_2 - \frac{mE_1 + mE_3}{2}}{mI}$$

The instruments that can be used for this purpose are multicomination meter, megger, millivoltmeter and microammeter.

A-1.1.3 The following factors should be considered to avoid erroneous data when making resistivity measurements by this method:

- a) When passing current between the two outer terminals, polarization may occur causing inaccurate measurement. To avoid this, a switch may be inserted in the current circuit and the current applied for only short intervals of time, or a pulsating dc or ac may be utilized as is the case when using a vibroground or megger. Incidentally, the vibroground and megger read directly in ohms and, therefore, the calculation of resistance is unnecessary. The resistance value can be converted to resistivity.

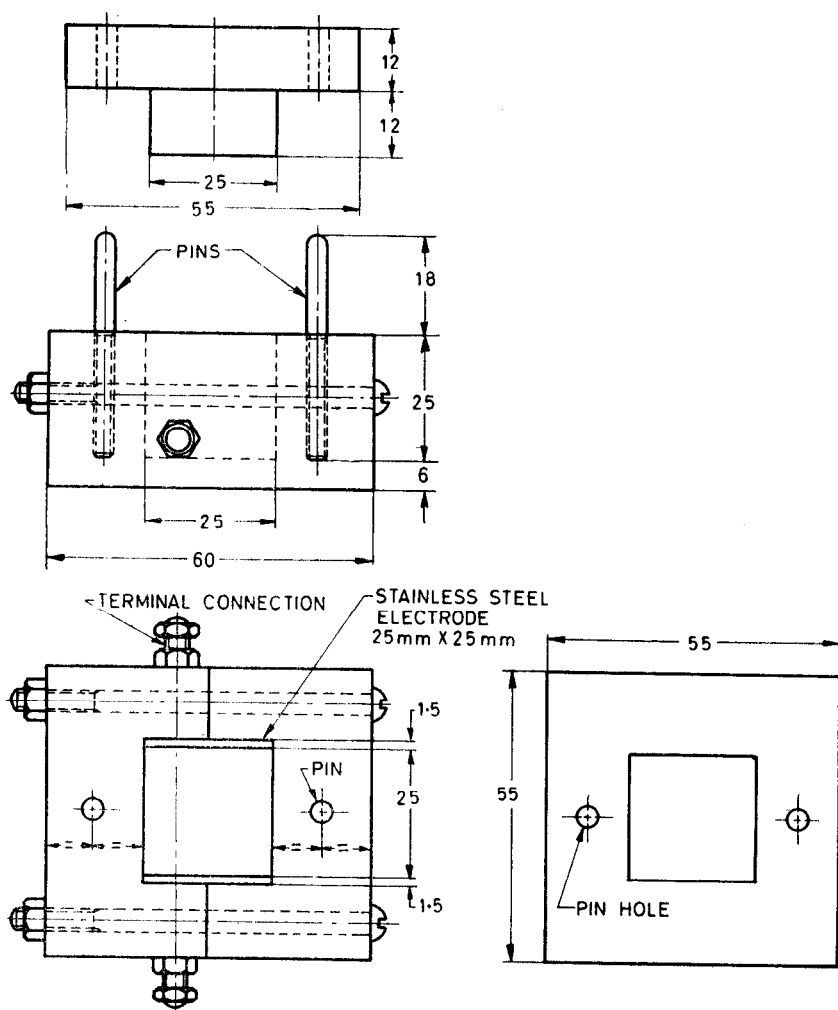
- b) In making the potential measurement between the two inner terminals, it is necessary to use a sensitive voltmeter, potentiometer-type voltmeter, or vacuum tube voltmeter in order to achieve accurate results.
- c) A natural potential between the two centre terminals may exist and, therefore, it is important to observe the change in potential.
- d) It should be noted that this type of measurement indicates the average resistivity to an approximate given depth (equal to the spacing between the terminals). Unless the soil is quite homogeneous, it is necessary to take a series of test measurements at varying terminal (pin) spacings in order to evaluate the degree of soil resistivity change between soil strata. If the soil on the immediate surface is of high resistivity, it will cause deeper readings to appear higher than they actually are and, conversely, extremely low resistivity soil on the surface will tend to decrease observed resistivity values at greater depths.
- e) Making this type of measurement directly over a large bare metallic structure (in a high resistivity environment) will tend to reduce the resistivity due to the relatively high conductivity of the metal.

A-1.1.4 This method indicates average soil resistivity and not specific resistivity. Therefore, it is advisable to make a series of tests at any given location using a number of different pin spacings (or depths) in order to obtain an indication of the resistivity trend throughout heterogeneous strata. This procedure may be standardized by taking a set of readings at approximate pin spacings of 80, 165, 320 and 480 cm.

A-1.2 Laboratory Test

A-1.2.1 For disturbed soil samples collected from the exposure sites, resistivity shall be measured in soil box.

A-1.3 The circuit consists of two polished steel electrodes having faces 25 mm apart to form a cubical cell (as shown in Fig. 7). The soil to be tested shall be compacted in this cell under a standard pressure (under 500 g weight). The resistance of the soil cube shall be determined by measuring the resistance between the electrodes with an alternating current using Wheatstone bridge in successive stages by adding fractions of conductivity water (the amount of water determined previously from water holding capacity of the soil) stepwise until minimum constant value of resistance is observed.



All dimensions in millimetres.

FIG. 7 SOIL RESISTIVITY BOX FOR DETERMINING SOIL RESISTIVITY IN LABORATORY

APPENDIX B

(Clause 13.1.2)

DETERMINATION OF THE TOTAL ACIDITY OF SOILS

B-1. The determination of total acidity of soils is somewhat difficult because of the slight solubility of soil acids. The details of the procedure followed in determining acidity by the difference method as described by Denison are as follows:

The capacity of the soil to absorb exchangeable bases was first determined. A 25 g sample of soil was placed in a 250-ml Erlenmeyer flask together with about 1 g of calcium carbonate and 150 to 200 ml of 1 N sodium chloride solution that had been heated to 80-90°C. The mixture was maintained at this temperature for 1 hour, with occasional shaking. The mixture was then poured into a 400-ml bottle and shaken overnight in an end-over-end shaker and also for 2-hour periods on 2 succeeding days. After standing another night the extract was decanted and filtered into a 1-litre beaker. Then 200 ml of 1 N sodium chloride solution was added to the soil at room temperature. The mixture was shaken for 1 hour, allowed to settle, and the extract then decanted through the filter as before. This process was repeated until 1 litre of extract was obtained. For the final filtration, the entire quantity of soil was poured on the filter and washed. The 1-litre extract was then mixed thoroughly, and the calcium in a 400-ml portion was determined gravimetrically. The quantity of calcium equivalent to the solubility of calcium carbonate in 1-litre of 1 N sodium chloride, was subtracted from the value thus obtained.

B-2. The quantity of replaceable calcium in the soil was determined in a manner similar to the determination of the unchangeable base capacity, except that no calcium carbonate was added and the shaking was limited to 18 hours. For those soils in which calcium carbonate occurred naturally, a correction was made for the calcium that had been dissolved as carbonate by the salt solution, this quantity was calculated from the amount of bicarbonate in solution, which was estimated by titrating an aliquot portion of the extract with standard acid to the colour change of methyl orange. The total acidity of the soil was obtained by subtracting from the exchange capacity of the soil the absorbed calcium found to be present.

B-3. Ewing devised a shorter method that duplicated results of Denison's method within about 15 mg equivalents per 100 g of soil. Ewing's method is as follows:

Two 5-g portions of the air-dried soil, previously pulverized and passed through a 20-mesh sieve, are placed in two 25 × 200-mm test tubes, and then 25 ml of normal sodium chloride solution is added to

each tube at room temperature. One millilitre of 0.2-N sodium carbonate solution is pipetted into one tube and 2 ml into the other. (One millilitre is equivalent to 4 milligram equivalent of acid per 100 g of soil for the 5-g sample.) The pH of the more alkaline solution is then determined. If the pH is found to be below 8.2 ml more of the carbonate solution are added to each tube and the process repeated until the pH of the more alkaline solution is above 8. The tubes are allowed to stand, with occasional shaking, until the solutions are in equilibrium with the soil and show no further changes of pH with time. The solutions usually reach equilibrium after a period of 24 hours. The pH of the solution in each tube is then determined. Usually the resulting pH values are so near to pH 8 that by interpolation or extrapolation the amount of alkali required to bring the soil to pH 8 can be determined. For example, if 12 milligram equivalent (3 ml) of the carbonate solution give a pH of 7.7 when in equilibrium with the soil and 16 milligram equivalent (4 ml) give a pH of 8.1, the acidity of the soil will be 15 milligram equivalent/100 g. The titration curve is assumed to be a straight line through the range of interpolation and extrapolation.

APPENDIX C

(*Clauses 13.1.8 and 13.1.9*)

DETERMINATION OF VOLUME EXPANSION AND PORE SPACE OF THE SOIL

C-1. The test shall be carried out in cylindrical boxes of brass, 16 mm long and 50 mm in diameter and carrying a perforated bottom with a split brass ring of about the same diameter as the base to hold the filter paper in position in the bottom of the box.

C-2. The oven (at 110°C) dry soil which has passed a 1-mm sieve, shall be sieved through a 100 mesh sieve in order to break up the compound particles; the portion passing the sieve shall be remixed with the particles held by the 100 mesh sieve. After fitting a piece of filter paper in position, the box shall be weighed. It shall then be filled with the soil sample in a systematic way, so that the packing may be as uniform as possible. Eight to ten gram of the sample shall be added at a time, and the box tapped on the bench after each addition. When the box is nearly full, sufficient soil shall be added to allow the surface to be struck off flat with a spatula. The upper edge of the box shall then be tapped smartly with the edge of the spatula and more soil added. This shall be struck off flat as before, and the process repeated until very slight settling of the soil occurs, when the surface shall be finally struck off flat and the box and contents weighed. The box and contents shall then be placed in a flat-bottomed dish

containing about 6 mm depth of distilled water and left overnight. When a number of boxes are placed in the same dish, additions of water shall be made at intervals to keep the level constant. During the wetting considerable movement takes place, the top of the block of soil retreats from the sides of the box, and at the same time rises in height. When the interstices are saturated, the wet soil shall expand to the sides of the box, but the vertical expansion remains. The next morning the boxes shall be rapidly dried on the outside, weighed and replaced in water for a few minutes. The portion of the soil which has expanded above the top of the box shall be removed with a razor blade which shall be held at a slight angle with the horizontal, placed on the edge of the box and then drawn across the top. The surplus soil shall be transferred from the razor blade to a glass dish and weighed. Any soil adhering to the upper side of the razor blade shall not be placed in the dish, but shall be replaced in the box to which it belongs. The box and residual soil shall be weighed, and then placed together with the dish containing the surplus soil in an oven to be dried. When dry they shall be allowed to cool in a desiccator and weighed again.

C-3. The necessary weighings and measurements shall be as follows:

- | | |
|--|----------|
| a) Weight in g of box + filter paper | <i>a</i> |
| b) Weight in g of box + filter paper + saturated residual soil | <i>b</i> |
| c) Weight in g of box + dry paper + oven-dry residual soil | <i>c</i> |
| d) Weight in g of glass dish | <i>d</i> |
| e) Weight in g of glass + saturated surplus soil | <i>e</i> |
| f) Weight in g of glass + over-dry surplus soil | <i>f</i> |
| g) Internal volume of box in ml. | <i>v</i> |

C-4. From the above measurements the following results are obtained:

a) Pore space, percent = $\frac{(b - a) - (c - a)}{v} \times 100$

Correct $(b - a)$ for the water in the filter paper.

b) Volume expansion of 100 ml of soil

$$= \frac{(e - d)/\text{sp gr of saturated soil}}{v} \times 100$$

where sp gr of saturated soil = $\frac{(b - a)}{v}$

APPENDIX D

(*Clauses 16.1 and 17.1*)

PROFORMAS RECORDING THE DATA OF UNDERGROUND CORROSION OF METALS

D-1. The standard proformas for recording the results shall be as proformas A, B, C, D, E, F and G.

PROFORMA A PARTICULARS OF THE SOILS AT THE TEST SITES

SITE NO.	SOIL TYPE	LOCATION	DESCRIPTION OF SOIL PROFILE	TOPOGRAPHY	DEPTH OF EXPOSURE OF SPECIMENS

PROFORMA B DETAILS OF TEST SPECIMENS

IS : 7808 - 1975

MATERIAL	IDENTIFICATION		NO. OF SPECIMEN BURIED	FORM	NOMINAL WIDTH OR DIAMETER	LENGTH	THICKNESS	METAL ANALYSIS FOR FERROUS SPECIMENS							
	Symbol	Year and month buried						C	Si	Mn	P	Cr	Ni	Mo	Other Elements
								Metal Analysis for Non-ferrous Specimens							
								Main Metal		Auxiliary Metal		Other Elements			
								Coated Metal Specimens							
								Coating Material		Thickness of Coating/Amount of Coated Metal per Unit Area of Metal Surface				Base Metal	
<p>NOTE — Analysis of the metals to be done in accordance with the relevant Indian Standard.</p>															

PROFORMA C MECHANICAL AND CHEMICAL ANALYSIS OF THE SOILS AT THE TEST SITES

SOIL		LOCATION	MECHANICAL ANALYSIS			CHEMICAL ANALYSIS								TOTAL SOLUBLE SALT CONTENT	ACIDITY	pH	RESISTIVITY AT 30°C
No.	Type		Sand Per-cent	Silt Per-cent	Clay Per-cent	Na + K (as Na)	Ca	Mg	CO ₃	HCO ₃	Cl	SO ₄	NO ₃	NO ₂			Field 'Lab Method' Method

**PROFORMA E LOSS IN WEIGHT AND RATE OF CORROSION OF TEST SPECIMENS
(AVERAGE OF 2 SPECIMENS)**

SOIL		DURATION OF EXPOSURE (YEARS)	LOSS IN WEIGHT (IN g/cm ²)						RATE OF CORROSION (g/dm ² /yr)							
No.	Type		Mild Steel		C. I. (Spun) Pipe	C. I. (Horizontally Cast) Pipe	Copper Plate	Aluminium Pipe	Galvanised Steel Pipe	Mild Steel		C. I. (Spun) Pipe	C. I. (Horizontally Cast) Pipe	Copper Plate	Aluminium Pipe	Galvanised Steel Pipe
			Pipe	Plate						Pipe	Plate					

**PROFORMA F NATURE OF CORROSION ATTACK, AND MAXIMUM PIT DEPTHS ON
TEST SPECIMENS (AVERAGE OF 2 SPECIMENS)**

SOIL		DURATION OF EXPOSURE (YEARS)	NATURE OF CORROSION ATTACK						MAXIMUM PIT DEPTH IN MICRONS AND NUMBER OF LARGE PITS							
No.	Type		Mild Steel		C.I. (Spun) Pipe	C.I. (Horizontally Cast) Pipe	Copper Plate	Aluminium Plate	Galvanised Steel Pipe	Mild Steel		C. I. (Spun) Pipe	C. I. (Horizontally Cast) Pipe	Copper Plate	Aluminium Pipe	Galvanised Steel Pipe
			Pipe	Plate						Pipe	Plate					

PROFORMA G METEOROLOGICAL DATA SITE

MONTH	TEMP.			R. H.			DEW	RAIN-FALL	NO. OF RAINY DAYS	SO ₂ POLLUTION	NaO POLLUTION
	Max.	Min.	Av.	Max.	Min.	Av.					
Jan.											
Feb.											
March											
April											
May											
June											
July											
August											
Sept.											
Oct.											
Nov.											
Dec.											

INDIAN STANDARDS

ON

CORROSION PROTECTION

IS:

- 3531-1966 Glossary of terms relating to corrosion of metals
- 3618-1966 Phosphate treatment of iron and steel for protection against corrosion
- 4180-1967 Code of practice for corrosion protection of light gauge steel sections used in building
- 4777-1968 Performance tests for protective schemes used in protection of light gauge steel against corrosion
- 5555-1970 Code of procedure for conducting field studies on atmospheric corrosion of metals
- 6005-1970 Code of practice for phosphating of iron and steel

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